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Bulletin No. 95 - Codling Moth Work in 1904: The Relative Value of Early and Late Sprays

E. D. Ball

E. G. Peterson

EXPERIMENT STATION

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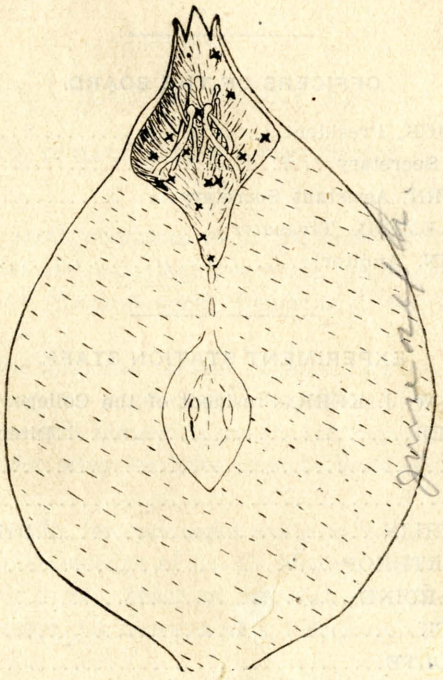

(Poison in the Calyx Cup.)

CODLING MOTH WORK IN 1904

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CODLING MOTH WORK IN 1904

THE RELATIVE VALUE OF EARLY AND LATE SPRAYS.

E. D. BALL AND E. G. PETERSON.

The codling moth continues to be the most serious pest of the Utah horticulturist and was therefore made the main subject of investigation by the Entomological Department for the season of 1904.

In spite of the immense amount of work that has been done on this subject by various entomologists in this and other countries, several vital points still remain unknown and many more that have been worked out for other localities must be verified and adapted to our conditions.

The first requisite for successful work on this insect in any locality is a definite knowledge of its life history under the particular conditions existing there. Much of the work that has been done in the past has neglected this factor, and is, therefore, of little value for comparison.

As nothing had been attempted along this line for this region, the work of the season of 1903 was largely devoted to this problem, and a complete life history chart was published in Bulletin 87. Along with this study, a preliminary test of the value of early sprays was made on Mr. Campbell's orchard and, although it had been very wormy the year before, 90 per cent of the apples picked were sound. This orchard was young and nicely cared for and was nearly a quarter of a mile from any unsprayed tract; a combination of favorable conditions not found in the average Utah orchard and which must be understood in order to appreciate the real value of this experiment.

PLAN OF THE EXPERIMENT.

The questions in connection with the relative value of early and late sprays and the different methods of applying them are among the most important still before the western fruit grower. The majority of orchardists spray at fairly regular intervals throughout the season and use the same methods for all applications. That this practice can be improved upon is unquestioned, but, before any rational and permanent method can be devised, it will be necessary to carefully and accurately determine the value of each spray by each method and under different conditions of worminess.

With the two definite broods of the insect established as a basis upon which to work, it was determined to attempt to test the relative value of early and late sprays. To do this accurately, it was necessary to work out one of the unsolved problems of the subject and devise some method of correctly dividing the damage done by this pest between the respective broods of the insect. As soon as this was accomplished, it would be possible to determine whether the early sprays were of any value in killing worms in the second brood, and, with that factor determined, then the real value of the late sprays, when applied with the others, could be determined. With these two factors solved, it would then be possible to determine where the worms were killed in each brood and actually test what before has been, in part at least, a theory.

From these facts it will be seen that the accurate separation of the total worminess into that done by each brood is the key that unlocks the door to more than one of the present problems connected with spraying, and on the accuracy with which this was done depends the entire success or failure of the season's experiments.

Summing up the plan of the year's work, it was to discover the following things:

1. The relative value of early and late sprays.
   (a) The value of early sprays on the first brood.
   (b) The value (if any) of the early sprays on the second brood.
   (c) The value of the later sprays on the second brood.
   (d) How and where the different sprays kill the worms.
   (e) Miscellaneous information in connection with the above.

2. A method of accurately separating the work of the first brood of worms from that of the second.

The method of separating the broods, while of the first importance, is placed last because after all it is only a means to an end and not the end sought.

LOCATION AND DESCRIPTION OF ORCHARDS USED.

In selecting an orchard for this work, it was necessary to find one that was badly enough infested so that there would still be a large number of wormy apples left after the early sprays in order to test the value of the late ones when applied on the same trees.

Tests of this kind, where the results on one tree must be compared with those on another, are of little value unless the entire series of experiments is carried on on a single variety of apples under similar conditions and bearing somewhere near the same number of apples. Even then the results are open to the objection that they would only hold true for that particular variety so that a thorough test should be carried on in duplicate series on several varieties if possible.

Two orchards were found that fulfilled all the requirements with regard to worminess and also contained solid blocks of single varieties large enough to carry out a full series of tests. One of these was owned by Mr. Hoggan and the other by Hon. Thos. Smart. Mr. Smart's orchard was in two separate tracts, one being managed by Mr. J. H. Hatch and the other by Mr. Smart himself. These two tracts are referred to as the Smart orchard and the Hatch orchard respectively, for convenience.

The SMART and HATCH ORCHARDS together contain about four acres joining the town of Logan on the east, and as will be seen from Chart I, are only a few blocks from infested trees in town lots. They had not been pruned, cultivated or sprayed for several years and both were badly infested the year before. The apples were mostly stored in a large fruit cellar located in the angle between the orchards. During the summer evenings there is usually a canyon breeze blowing in about the direction of the large arrow and most of the moths from the cellar and also from the town lots were blown down upon the Hatch orchard, and especially upon the end nearest town, with the result that this end was very badly infested late in the season. The other end of this orchard, and the first few rows of the Smart orchard next to the cellar and town, received quite a

number of outside moths from these sources, but not nearly as many as in the first case. Just what per cent of moths came from each source, it is, of course, impossible to say. In the diagram the relative amount of outside infestation is roughly shown by the different

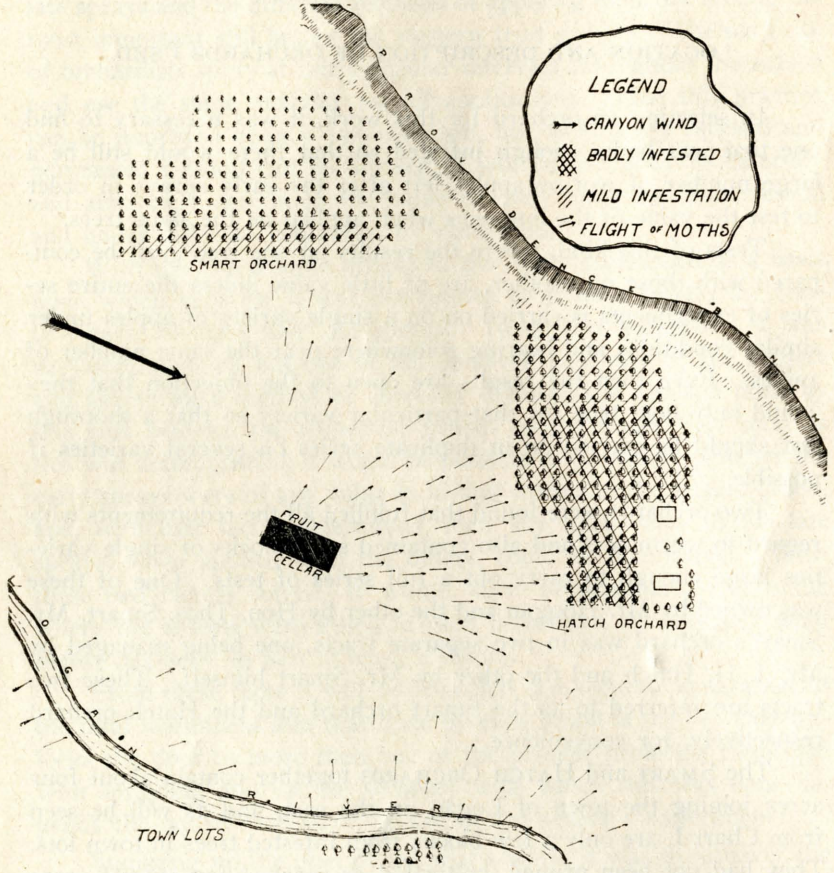

CHART I—LOCATION AND CONDITION OF ORCHARDS SPRAYED.

shadings and an attempt has been made to account for it by the probable course of the moths, from the different sources, as indicated by small arrows. The further side of the Smart orchard probably received a few moths from the more infested portions and a few from some unsprayed trees in a thicket above; but most of its worms came from the moths that hatched out in the orchard itself, these alone being nearly enough to make every apple wormy if it had not been

sprayed. Three varieties of apples were in large enough blocks to carry a full series of experiments, and, as it happened that each of these blocks was in a different condition of infestation as shown above, this matter will be discussed further under these varieties. That the varieties themselves had nothing to do with the difference in infestation is shown by the fact that all the mixed trees in the different locations were similarly affected.

The *Sutton Beauty* trees were located in the very worst section of the Hatch orchard where they received moths from both the fruit cellar and the town lots. The unsprayed tree had more worms than apples, although it was entirely surrounded by sprayed trees. Without any spraying these apples would have had four or five worms to an apple. As it was, many of the apples on the unsprayed tree had two worms and some had three, while a few escaped without any.

This variety was in fine shape when first sprayed, the calyx cups being about one-third closed and the trees bearing heavily.

The *Ben Davis* were tested in both orchards and in both cases the trees used happened to be in the part where there was only medium outside infestation. The calyx cups were in fine shape at the time of the first spray—a little too open if anything—but it was an off year for this variety and none of the trees bore more than a third of a crop. While this block had only about one-third as many worms as in the case above, still, on account of the short crop of apples, conditions were very little better, and there would have been more than one worm to the apple without spraying.

The *Esopus* trees used in the test were all located near the middle of the Smart orchard, and were fairly free from outside infestation. Some moths evidently flew in from the Ben Davis along the edge and a few more from some unsprayed trees above. The unsprayed tree in this lot, although surrounded by sprayed ones to which its extra moths would scatter, was about half wormy. It had worms enough in the first brood, however, so that, with only an increase of five times, nearly all the apples would have been destroyed if the rest of the orchard had been like it. The calyx cups were too nearly closed on this variety for the best results in the first spraying. These trees bore very irregularly also, some being well loaded while others would have apples only on one branch or one side.

Two *Ralls* used by mistake were in the badly infested portion. The two *Missouri Pippins* on which the heavy spray was tested

were just beyond the *Esopus*. The *Red Astrachan* was with the *Esopus* and was used by mistake for one of them.

The HOGGAN ORCHARD of an acre and a half is located in the southern edge of the town of Providence just outside of the direct line of the canyon breeze bearing moths from the town lots. Three varieties, Gano, Ben Davis, and Lawver are represented in equal blocks. All are young trees and fairly well cultivated, but were bearing rather light loads.

No spraying was done in the early part of 1904, and when the trees were examined, August 4th, they were found to average 320 wormy apples per tree of which 125 still remained on and the remainder had fallen off.

This was considered a good opportunity of testing the value of the late sprays in a wormy orchard where no early sprays had been applied, and accordingly, two trees of each variety received the three late sprays on the same days and in the same way as those in the other test. Records were then kept on these six trees and on six others unsprayed.

The CAMPBELL ORCHARD of five acres was the one used in last year's two- spraying tests, and for the Ben Davis block, which was about half of the orchard, the results were almost 90 per cent sound apples at picking time. The rest of the orchard is badly mixed, some of the varieties not bearing, which others were quite wormy. As a whole, however, the orchard started the season of 1904 with a very much smaller number of worms from over winter than the Smart and Hatch orchards or than it had started with the previous year. Consequently, with the same kind of treatment this season, this orchard should give results that would be as much better than those of the other orchards as its number of worms was less at starting time.

METHODS USED IN THE EXPERIMENT.

With the exception of the nine unprayed checks, the entire Smart and Hatch orchards were given two early sprayings using Paris green at the rate of one pound to 120 gallons of water. The first spray was applied just after the blossoms fell, May 28th to June 1st, and the second one from June 10th to 14th. The poison was kept thoroughly agitated in the barrel so as to be distributed evenly. To do this the paddle agitators on the pump were lengthened and

each barrel of the mixture was shaken two or three times as it was sprayed out.

The largest size of barrel pump with a packed plunger was used and to it was connected 30 feet of seven-ply hose and a ten-foot bamboo extension pole. On the end of the pole was a brass Y with one end capped and a nozzle on the other, giving an angle with the pole of about thirty degrees. For the first two sprays, an eight foot step ladder was firmly tied into the wagon box and the spraying was all done from a seat on the top of this ladder. A bordeaux nozzle set so that, with a pressure of 85 pounds, it would throw a flat spray of fine drops four of five feet before breaking into a mist, was used, and care was taken to see that the pressure was kept up to that point.

The wagon was driven between two rows, and half of each sprayed. Two stops were made at each tree where it was of any size. By using the angle on the end of the pole, it was possible to spray straight down into the upper part of the tree, straight in where the blossoms came out on the sides and nearly straight up into the blossoms that hung below. In this way, every calyx cup on the tree had the poison driven straight into its open throat at least once, and, by spraying from four points for each tree, nearly all the blossoms would be gone over twice. Care was taken to see that the nozzle was held within a foot or two of the blossoms and the spraying was continued until the tree was freely dripping.

One-half of the unsprayed trees in these orchards and as many more of those that had the two early sprays were given three late sprays. The first one of these sprays was applied August 4th, the second August 18th, the last September 2nd. They were applied with the same pump and outfit, except that a Velmorel or Mistry nozzle was used and spraying was stopped as soon as the tree began to drip.

All of the trees in the experiment were banded, and these bands were examined every three days, the worms counted and recorded. The remainder of the orchard was not banded and the worms caught under the bands on the check trees did not more than make up for the extra worms on the unsprayed trees. The orchard then, as a whole, was in practically the condition of an ordinary two-sprayed, but not banded one. The windfalls were all picked up at frequent intervals from the time the apples set until picking time. Each windfall was examined to see if it was sound or wormy and all wormy

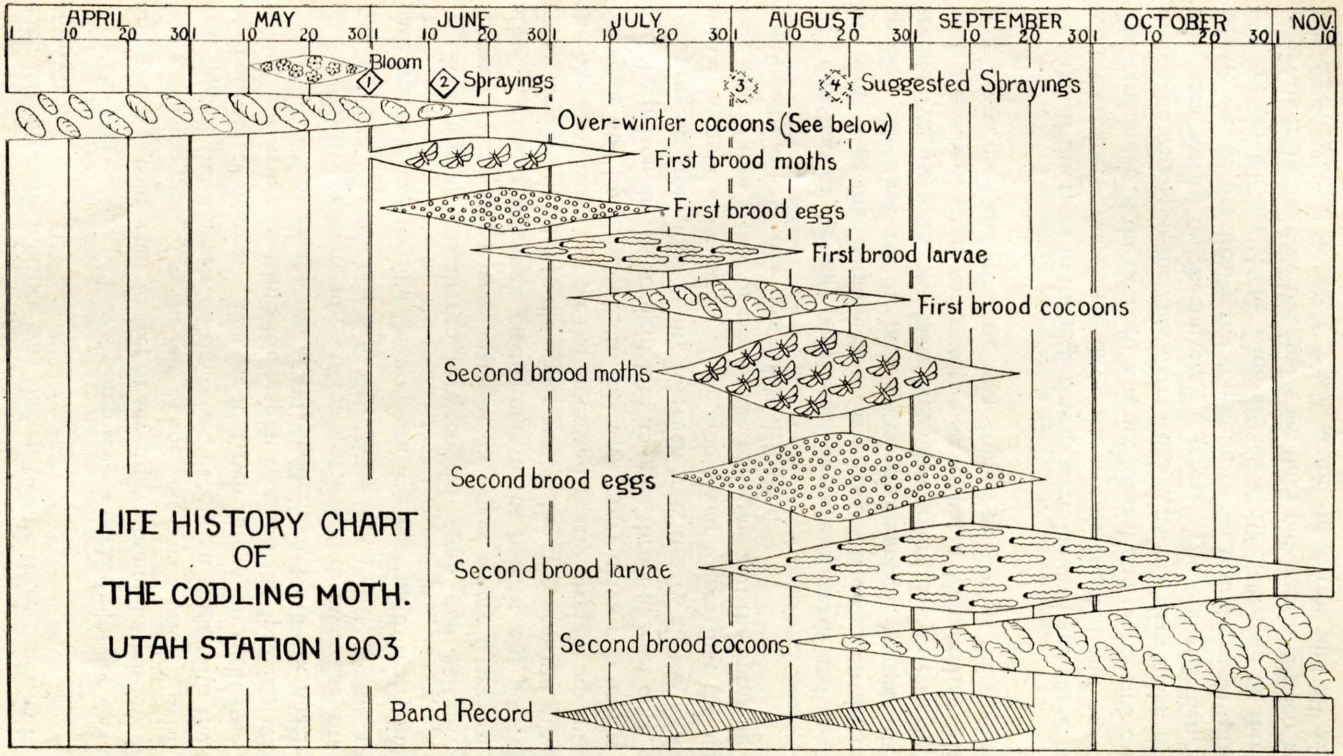

CHART II—THE LIFE HISTORY OF THE CODLING MOTH.

ones were further examined to see whether the worm entered at the calyx or somewhere on the surface of the apple.

All apples on the trees were gone over between August 1st and 3rd, and all those found wormy were examined to see whether the worm entered in the calyx or through the saide. At picking time, all the apples were counted, the wormy ones separated and examined for calyx and side holes.

UNSPRAYED TREES IN A SPRAYED ORCHARD.

Where only a few trees are left unsprayed in a large orchard the moths that hatch from them scatter over the adjoining trees to lay their eggs, and, as a result, there will not be nearly as many worms on these unsprayed trees in the second brood as there would have been if they had been surrounded by unsprayed trees like themselves, each of which was sending out moths to infest their neighbors. The unsprayed checks are not then a fair basis for estimating the worminess of an orchard or for testing the effect of late sprays.

SEPARATION OF THE WORK OF THE TWO BROODS.

As much of the success of the season's work hinged upon the accurate separation of the damage done by the two broods, considerable time was spent in working out this problem. The life-history chart as worked out in 1903 was used as a guide to this part of the work, and is here reproduced as Chart II in order to illustrate the methods used.

This chart was the result of a large amount of very careful work the previous year and each step was again carefully verified as the season advanced. The only material difference found was that, as the late spring was warmer than in 1903, the first brood of worms came on a little earlier. This is no doubt nearer the normal condition, as the spring of 1903 was cold and wet at the time the moths appeared. The summer of 1903 was, however, excessively hot and the worms developed rapidly, while the past season was varied with several cold rains so that by the time of the change in broods there was but little difference in time and the bulk of the second brood came on even later than that of the year before.

By reference to the band record of this chart, it will be noticed that for about five days on either side of August 10th there were but

few worms leaving the apples and coming under the bands. Some of these worms were, however, the last of the first brood and some were the first of the second brood, but the entire number for the ten days was very small in comparison with either brood. The total number of those in doubt being only about six per cent of the first brood and less than that of the second.

The average life of a worm in the apple at this season is slightly less than 20 days. Then, if the apples on a tree were examined about ten days before the division of the broods, the worms that would not come down until that time would be found scarcely half grown. In accordance with these ideas and as the result of careful observations on a number of trees, August 1st was found to be about the right time to attempt the separation of the broods. In the three days following this date, every apple on the check trees was carefully examined, and all found containing worms over one-fourth grown were recorded as first brood wormy. In carrying this out, it was found that in but few cases was there any doubt as to which brood a worm belonged, very few of the second brood having started at this time and most of these being very small.

RESULTS UP TO AUGUST 1ST.

(The First Brood Table.)

The number of first brood wormy found on each tree August 1st, together with all windfalls from that tree up to that date, should give the damage done by the worms of the first brood. These results have been brought together in Table I. The sound apples on the trees were not counted at this time. The numbers given are the result of subtracting the wormy apples then on the trees from the totals from then on to the end of the season as shown in Table II. They are introduced here to show the actual condition of worminess of the trees at the beginning of the second brood and the percentage the first brood wormy bore to the total apples from the trees.

TABLE I—FIRST BROOD SUMMARY.

(Results to August 1st.)

Tree No.	Times Sprayed	Windfalls					On Trees				Totals					Variety
		Wormy			Sound	Total	Wormy			Sound	Wormy			Sound	Total Apples	
		Calyx	Side	Total			Calyx	Side	Total		Calyx	Side	Total			
1	2	8	12	20	63	83	2	9	11	2280	10	21	31	2343	2374	Sutton Beauty.
2	2	6	21	27	42	69	0	10	10	2068	6	31	37	2110	2147	" "
3	1	70	74	144	60	204	39	18	57	1341	109	92	201	1401	1602	" "
4	1	70	52	122	63	185	42	21	63	1197	112	73	185	1260	1445	" "
5	0	172	99	271	52	323	117	51	168	1065	289	150	439	1117	1556	" "
6	2	11	19	30	59	89	3	9	12	1737	14	28	42	1796	1836	" "
7	2	1	9	10	26	36	0	9	9	316	1	18	19	342	361	Ralls.
8	0	34	45	79	17	96	34	60	94	178	68	105	173	195	368	"
9	0	85	23	108	19	127	52	20	72	182	137	43	180	201	381	Ben Davis.
10	2	0	6	6	25	31	0	2	2	166	0	8	8	191	199	" "
11	2	8	17	25	117	142	1	10	11	525	9	27	36	642	678	" "
12	0	91	43	134	98	232	52	28	80	440	143	71	214	538	752	" "
13	0	48	16	64	42	106	58	12	70	373	106	28	106	415	521	" "
14	2	14	12	26	213	239	4	4	8	358	18	16	34	571	605	" "
15	2	0	0	0	37	37	0	2	2	285	0	2	2	285	287	Red Astrachan*
16	0	18	10	28	77	105	66	54	120	1514	84	64	148	1591	1739	Esopus.
17	soak	3	3	6	30	36	1	1	2	1645	4	4	8	1675	1683	Missouri Pippin.
18	2	3	2	5	87	92	0	6	6	784	3	8	11	871	882	Esopus.
19	soak	1	1	2	63	65	1	4	5	1120	2	5	7	1183	1190	"
20	2	1	1	2	61	63	2	2	4	1048	3	3	6	1109	1115	Missouri Pippin.
21	2	0	7	7	208	215	3	8	11	1980	3	15	18	2188	2206	Esopus.
22	0	18	21	37	185	224	35	30	65	924	53	51	104	1109	1213	"

TABLE II—RESULTS FROM AUGUST 1 TO END OF THE SEASON.

Tree No.	Times Sprayed		Windfalls					Picked					Totals					Variety
	Early	Late	Wormy			Sound	Total	Wormy			Sound	Total	Wormy			Sound	Total	
			Calyx	Side	Total			Calyx	Side	Total			Calyx	Side	Total			
1	2	0	171	554	725	248	973	87	222	309	1009	1318	258	776	1034	1257	2291	Sutton Beauty.
2	2	3	63	116	179	302	481	57	83	140	1457	1597	120	199	319	1759	2078	" "
3	1	3	276	144	420	222	642	174	76	250	506	756	450	220	670	728	1398	" "
4	1	0	458	181	639	103	742	226	93	319	199	518	684	274	958	302	1260	" "
5	0	0	701	202	903	74	977	81	46	127	129	256	782	248	1030	203	1233	" "
6	2	0	146	370	516	242	758	63	149	312	777	989	209	519	728	1019	1747	" "
7	2	0	3	49	52	41	93	22	141	163	69	232	25	190	215	110	325	Ralls.
8	0	0	64	36	100	12	112	106	40	146	14	160	170	76	246	26	272	"
9	0	0	108	9	117	12	129	93	11	104	21	125	201	20	221	33	254	Ben Davis.
10	2	0	5	24	29	43	72	6	12	18	78	96	11	36	47	121	168	" "
11	2	0	42	44	86	93	179	31	144	175	182	375	73	188	261	275	536	" "
12	0	0	180	61	241	66	307	120	29	149	64	213	300	90	390	170	520	" "
13	0	3	80	17	97	66	163	69	41	111	142	253	149	58	208	208	416	" "
14	2	3	7	10	17	79	96	2	13	15	255	270	9	23	32	334	366	" "
16	0	0	128	50	178	131	309	425	229	654	671	1325	533	279	832	802	1634	Esopus.
17	soak	0	4	19	23	842	865	1	19	20	762	782	5	38	43	1604	1647	Missouri Pippin
18	2	0	15	30	45	140	185	36	141	177	428	605	51	171	222	568	790	Esopus.
19	soak	0	3	46	49	441	490	19	81	107	528	637	22	127	156	969	1127	"
20	2	0	6	31	37	398	435	1	44	45	572	617	7	75	82	970	1052	Missouri Pippin.
21	2	0	17	51	68	551	619	29	171	200	1172	1372	46	222	268	1723	1991	Esopus.
22	0	3	51	23	74	166	240	104	80	184	565	749	155	103	256	731	989	"
23	2	3	41	101	142	643	785	4	21	25	1151	1176	45	122	167	1794	1961	Sutton Beauty.
24	2	3	37	115	152	530	682	19	60	79	1449	1528	56	175	231	1979	2210	" "
25	2	3	6	20	26	256	282	22	22	44	480	524	28	42	70	736	806	Ben Davis.
26	2	3	3	23	26	348	374	12	21	33	396	429	15	44	59	744	803	" "
27	2	3	4	9	13	264	277	21	37	58	618	676	25	46	71	882	953	Esopus.
28	2	3	4	9	13	303	316	15	45	60	1530	1590	19	54	73	1833	1906	"

RESULTS FROM AUGUST 1ST TO THE END OF THE SEASON.

To increase the number of trees in the experiment and thus eliminate the possibility of individual variations affecting the main results sought, six new trees were taken in and used to test the value of the three late sprays. These trees had received the two early sprays the same as the twice sprayed checks. The windfalls under them were picked up and the trees examined August 1st the same as the others, but the results were not used in the first brood table as there might have been a few windfalls removed.

The windfalls from August 1st until picking time, the counts made on the picked apples and the totals of the two are shown in Table II. These results do no, however, show the damage done by the second brood as they include all wormy apples of the first brood left on the trees August 1st. It is necessary, however, to present the results in this way in order to get the material for some conclusions later on.

SUMMARY OF RESULTS—SMART-HATCH ORCHARDS.

Table III gives the total number of wormy and sound apples for each check tree in the Smart and Hatch orchards. For the wormy apples it shows just how many were produced by each brood and what number of the worms from them were caught under the bands. The figures for the first brood are from the totals of Table I, while those for the second brood are the results of subtracting the number of first brood wormy apples on the trees August 1st from the totals in Table II. In the case of the worms caught under bands, ten days more was allowed for the worms of the first brood to leave the apples so all worms caught before August 10th were included under the first brood. This date is some days earlier than the lowest part in the band record so it is doubtless conservative for the first brood.

TABLE III—SUMMARY OF RESULTS; SMART AND HATCH ORCHARDS.

Tree No.	Times Sprayed		First Brood				Second Brood				Totals						Variety
	Early	Late	Wormy Apples			B and Worms	Wormy Apples			Band Worms	Wormy Apples			Band Worms	Sound Apples	Total Apples	
			Calyx	Side	Total		Calyx	Side	Total		Calyx	Side	Total				
1	2	0	10	21	31	25	256	767	1023	140	266	788	1054	165	1320	2374	Sutton Beauty.
2	2	3	6	31	37	25	120	189	309	46	126	220	346	71	1801	2147	" "
3	1	3	109	92	201	108	411	202	613	90	520	294	814	198	788	1602	" "
4	1	0	112	73	185	125	642	253	895	205	754	326	1080	120	365	1445	" "
5	0	0	289	150	439	284	665	197	862	275	954	347	1301	559	255	1556	" "
6	2	0	14	28	42	29	206	510	716	79	220	538	758	108	1078	1836	" "
7	2	0	1	18	19	10	25	181	206	94	26	199	225	104	136	361	Ralls
8	0	0	68	105	173	199	136	16	152	114	204	121	325	313	43	368	"
9	0	0	137	43	180	141	149	0	149	102	286	43	329	243	52	381	Ben Davis
10	2	0	0	8	8	5	11	34	45	20	11	42	53	25	146	199	" "
11	2	0	9	27	36	19	72	178	250	93	81	205	286	112	392	678	" "
12	0	0	143	71	214	86	248	62	310	173	391	133	524	259	228	752	" "
13	0	3	106	28	134	62	91	46	137	71	197	74	271	133	250	521	" "
14	2	3	18	16	34	4	5	19	24	13	23	35	58	17	547	605	" "
15	2	0	0	2	2	2	...	...	....	3	0	2	2	5	285	287	Red Astrachan
16	0	0	84	64	148	105	487	225	712	463	571	289	860	568	879	1739	Esopus
17	soak	0	4	4	8	1	4	37	41	16	8	41	49	17	1634	1683	Missouri Pippin
18	2	0	3	8	11	6	51	165	216	43	54	173	227	49	655	882	Esopus
19	soak	0	2	5	7	3	21	130	151	20	23	135	158	23	1032	1190	"
20	2	0	3	3	6	2	5	73	78	15	8	76	84	17	1031	1115	Missouri Pippin
21	2	0	3	15	18	14	43	214	257	152	46	229	275	166	1931	2206	Esopus
22	0	3	53	51	104	40	120	73	193	99	173	124	297	139	916	1213	"
23	2	3	12	25	37	...	39	118	157	14	51	143	194	14	1836	2030	Sutton Beauty
24	2	3	9	30	39	...	53	166	219	13	62	196	258	13	2021	2279	" "
25	2	3	10	26	36	...	26	33	59	20	36	59	95	20	853	948	Ben Davis
26	2	3	8	25	33	...	15	36	51	19	23	61	84	19	861	945	" "
27	2	3	4	12	16	...	23	39	62	14	27	51	78	17	1030	1108	Esopus
28	2	3	3	9	12	...	18	50	68	14	21	59	80	15	1981	2061	"

Chart III shows graphically the total results of the season's work on these orchards arranged by varieties. These varieties represent different conditions of infestion as has been explained and are arranged in order, the worst infested at the top. The Chart shows the number of the tree as given in Tables I, II and III, the variety, the number of early sprays and the number of late sprays

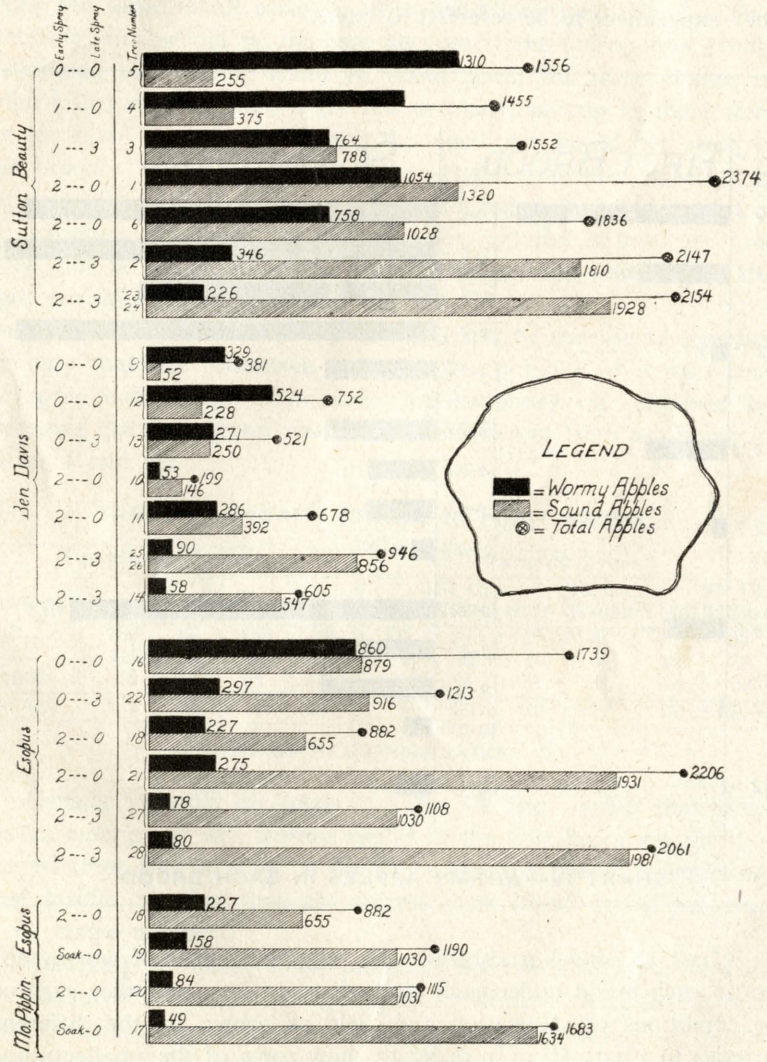

CHART III—SOUND AND WORMY APPLES ON EACH TREE.

applied to each tree. The black stripe shows the total number of wormy apples for the year, the ruled stripe below it shows the total number of sound on the same tree and the encircled cross shows the total number of apples that set on the tree. From this table may be obtained the general condition of infestation, the relative yield and a general idea of the comparative value of the different number of sprays under different conditions. The last four trees belong to another experiment to be referred to later.

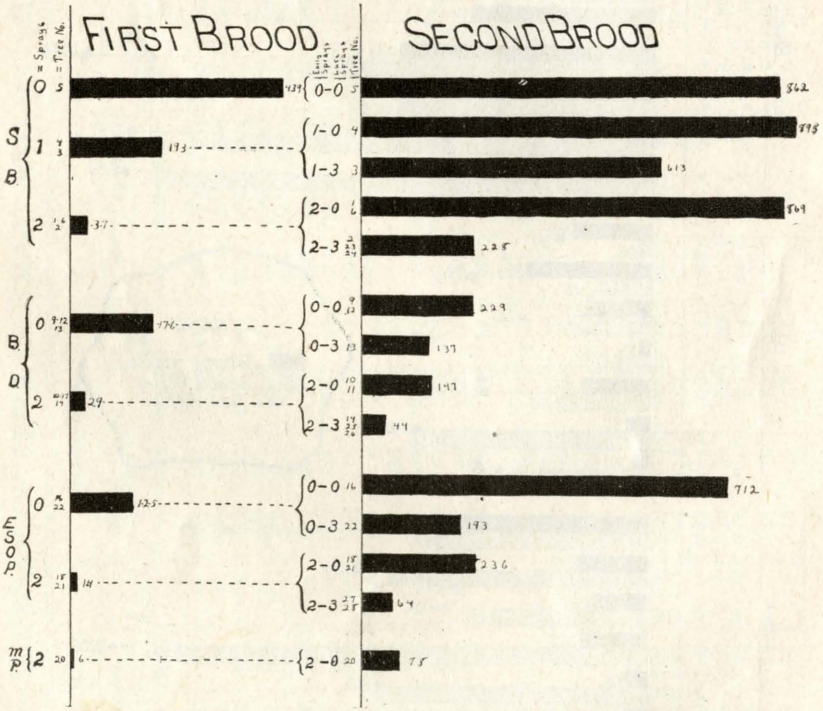

CHART IV—WORMY APPLES IN EACH BROOD.

Chart IV shows graphically the relative number of wormy apples in each brood under each kind of treatment and under each of the conditions of infestation and yield as shown by the different varieties in Chart III. In order to show some of the smaller numbers, it was necessary to double the scale of representation.

THE EFFECT OF TWO EARLY SPRAYS ON THE FIRST BROOD.

In the first brood the results of spraying should be nearly the same regardless of the number of worms in an orchard. The orchard that had the most worms before spraying would naturally have the most after, but the per cent of worms killed should be about the same in all cases if other conditions were equal. Theoretically, this would be the case because if the poison was evenly distributed the worms would all stand about the same chance of being killed whether there were few or many, as long as there were not too many for the apples, and this condition would not occur in this brood. This proved to be true in this case, the variation in per cent killed being no more than would naturally occur in different varieties. In fact, the wormiest lot had the largest per cent killed, due no doubt to the fact that the calyx cups were in just the right condition when sprayed.

Then for this brood all the varieties may be considered together the only material difference being in the number of worms that the spray had to kill. The following summary was obtained by averaging the first brood results on the different trees as shown in Tables I and III.

TABLE IV—WORMY APPLES IN FIRST BROOD.

	Unsprayed Trees.				Sprayed Trees.					
Variety	Calyx	Pr Ct. Calyx	Side	Total	Calyx	Pr Ct. Killed	Side	Pr Ct. Killed	Total	Pr Ct. Killed
S. B. ...	289	66	150	439	10	97	27	82	37	92
B. D. ...	129	73	47	176	9	93	20	57	29	84
Esopus ..	68	54	57	125	3	96	11	81	14	89
Average	162	66	85	247	7	96	19	78	27	89

WHAT SPRAYING DOES.

Considering only the totals in Table IV and we find that there was an average of 247 wormy apples in the first brood on the unsprayed trees and only 27 on the twice sprayed ones. Subtracting these results, we find that 220 worms were killed or 89 per cent of the entire number.

Referring to Table V we find that the twice sprayed trees in Mr. Campbell's orchard averaged only 11 wormy apples in the first brood. Calculating from the same basis of worminess as in the other orchards, this would show a reduction of 96 per cent in the number of worms as a result of two successive years of early spraying.

TABLE V—FIRST BROOD COUNTS—CAMPBELL ORCHARD.
(Second Year of Spraying.)

Tree No.	Windfalls			On Tree			Total Wormy	Variety
	Wormy		Sound	Womry		Sound (Esti-mated)		
	Calyx	Side		Calyx	Side			
1	0	1	61	0	4	800	5	Ben Davis.
2	0	2	43	0	11	500	13	" "
3	1	3	30	0	2	400	6	" "
4	0	1	46	1	1	450	3	" "
5	6	2	42	19	33	300	60	Ralls (sprayed once)
6	0	3	48	0	4	350	7	Carlyle Seedling.
7	0	11	44	0	3	150	14	Wolf River.
8	2	9	66	8	5	250	24	Pewaukee.
9	3	6	56	0	7	200	16	"
Av'r'ge	1	4	48	1	5	375	11	(Omitting No. 5)

These results show the value of early spraying and also that better results may be expected for each succeeding year that it is followed up. This is represented graphically in the first half of Chart V.

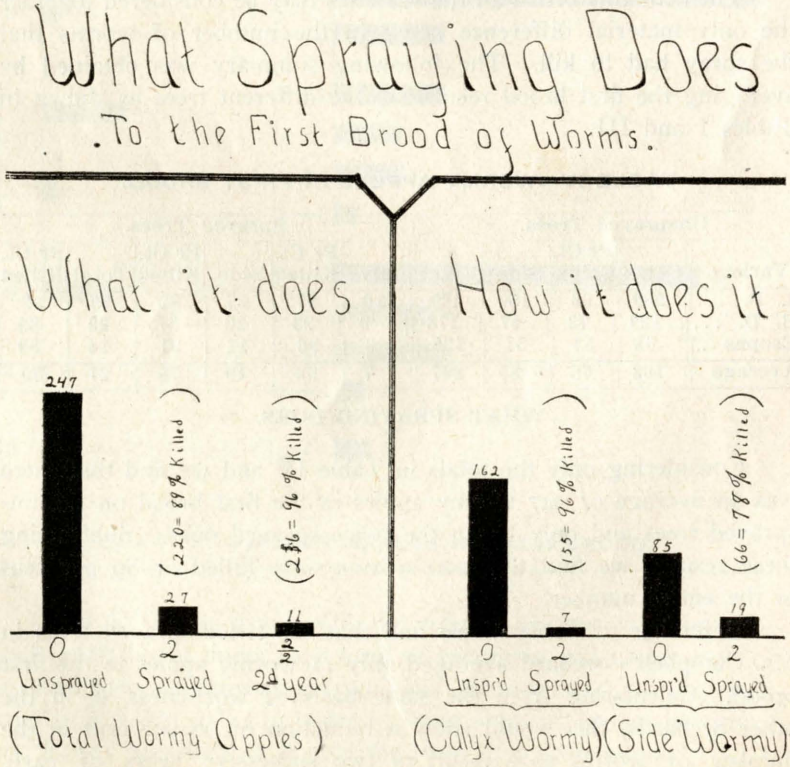

CHART V—EARLY SPRAYS ON THE FIRST BROOD.

HOW IT DOES IT.

Considering the wormy apples in Table IV from the standpoint of where the worms entered and it will be found that the unsprayed trees averaged 162 calyx wormy while the sprayed ones had only 7. Subtracting these results, it is found that 155 worms or 96 per cent of all those going in the calyx were killed. Comparing the side-wormy apples, the unsprayed trees averaged 85 while the sprayed ones had only 19, showing that 66 worms that would have gone in on the side had been killed or 78 per cent of the total side-wormy. These facts are illustrated in the second half of Chart V.

From this table it will be seen that an average of two-thirds of the worms went in the calyx on the unsprayed trees. Other tests have given averages from 70 to 85 per cent on different varieties, and practically all observers agree that the greater number of the first brood go in at this point. Consequently the method of spraying that places the greatest amount of poison in the calyx cup will, other things being equal, be the most likely to be successful. Judging by results, it would seem that these two sprays were almost perfect in this particular. Only four per cent of the worms that started succeeded in getting in the calyx, while 22 per cent of those on the side escaped the poison.

In examining the table, it will be noticed that the per cent entering the calyx was the lowest on the Esopus. This was no doubt due to two factors: First, the calyx cups on that variety closed early and so tightly that on some apples a worm could not readily enter and secondly, that the apples grew in clusters and thus afforded good hiding places where they touched. The per cent killed in each place was however fully up to the average.

CONDITIONS AFFECTING SECOND BROOD RESULTS.

So many factors enter into any consideration of the damage done by the second brood of worms that it is only by the most careful work and by comparison of results under different conditions that any accurate conclusions can be drawn.

All observers are agreed that the second brood of moths is much larger than the first. Definite statistics as to the relative numbers are however hard to obtain on account of the fact that these moths fly from one orchard to another at this season. Many other variable factors also enter into the problem and serve to complicate matters. Many writers have stated that the damage done by the

late worms was ten or more times as great as that done earlier in the season. Very few, if any, of these estimates were based on work in which there was an accurate separation of the damage done by the different broods, however, and so they are not conclusive. From work done by the senior author on a rather isolated orchard in Colorado and again on orchards in the midst of large tracts, it was concluded that, under ordinary orchard conditions, the late worms averaged something over five times as numerous as the early ones. All other writers have placed the ratio higher than this, so it is certainly conservative to use an increase of five times as a basis for some rather interesting calculations below.

Taking the 247 wormy apples shown in Chart V as a fair average for the first brood in an unsprayed orchard and, using it to calculate from, an orchard practically free from outside infestation might be expected to have 1482 wormy apples per tree during the season if unsprayed, 162 per tree if sprayed twice, and 66 the following year if again twice sprayed.

Taking the same increase as a basis again and we find that under the conditions presented by the Sutton Beauty in the first brood, without further outside infestation there might have been expected an average of 2634 wormy apples per tree if unsprayed, or more than one worm to an apple. In the same way for the Ben Davis sections, there would have been 1056 wormy apples per tree, or, on account of the light crop, again more worms than apples. In the Esopus section, on the other hand, there would have been only 750 worms per tree or less worms than the number of apples produced.

Remembering that these orchards were both sprayed twice, with the exception of a few trees used in this experiment, and that the worms on these trees were partly caught under bands, it will be readily seen on examining the tables that there was either a serious outside infestation or else an enormous increase from those already there.

The twice sprayed trees averaged only 27 wormy apples in the first brood, but, by consulting the tables to follow, it will be noticed that these increased to 417 or a little over 15 times as many in the second brood. This might be partly accounted for by moths that came from the seven unsprayed trees and from the wormier varieties to the others, if it were not for another factor that more than offsets this. By examining Chart VI it will be noticed that under

favorable conditions two-thirds of the second brood on the sprayed trees were killed. If this is true then the 417 represents only one-third of the real increase which in that case would have been 45 times.

EFFECT OF TWO EARLY SPRAYS ON THE SECOND BROOD.

Results in the latter part of the season are often obscured by the fact that more than one worm may enter an apple and as worms entering the calyx usually leave by some other hole and those entering the side may do so, it is very difficult to tell how many worms have been at work. No attempt was made to record the actual number of worms. The wormy apples from badly infested trees were sliced from time to time and an attempt made to estimate what per cent had contained more than one worm. In this work as high as four worms have been found in an apple at one time.

Another difficulty was encountered in the system employed for recording the wormy apples. All apples that had been entered through the calyx were recorded as calyx wormy while in many cases there was no doubt but that they were also side wormy, but to have recorded them as such in addition would have made the total number of wormy apples incorrect. The numbers given for calyx wormy in the tables represent the actual number of such apples while for the side worms the numbers given are too small in every case where there was a large number of worms. A method of correcting this in part has been devised and is used and explained below. Considering only the unsprayed trees and those with two early sprayings in Table III, the averages presented in Table VI may be obtained.

TABLE VI—SECOND BROOD AVERAGES.

(Effect of Early Sprays.)

Variety	Unsprayed Trees							Two Early Sprays				
	Calyx	Per Cent in Calyx	Per Cent Corrected	Side	Corrected	Total	Corrected	Calyx	Per Cent Killed	Side	Total	Per Cent Killed
Esopus	487	68	68	225	225	712	712	47	90	189	236	67
Ben Davis	198	86	62	31	106	229	304	41	79	106	147	51
Sutton Beauty...	665	77	51	197	638	862	303	231	65	638	869	33
Average	450	....	60	....	323	....	773	106	76	311	417	46

With the difference in infestation each block now presented a distinct problem which is best worked out and considered by itself and the varieties are therefore taken up separately, beginning with the least infected and consequently simpler conditions.

EARLY SPRAYS ON ESOPUS.

(Results in the Second Brood.)

As explained on page 69 there were fewer outside worms on this variety than on the others and consequently apples enough to go around even on the unsprayed trees. Under such conditions every worm killed would be represented by an additional sound apple and the full value of the spraying would be shown.

From Table VI we see that the unsprayed trees averaged 712

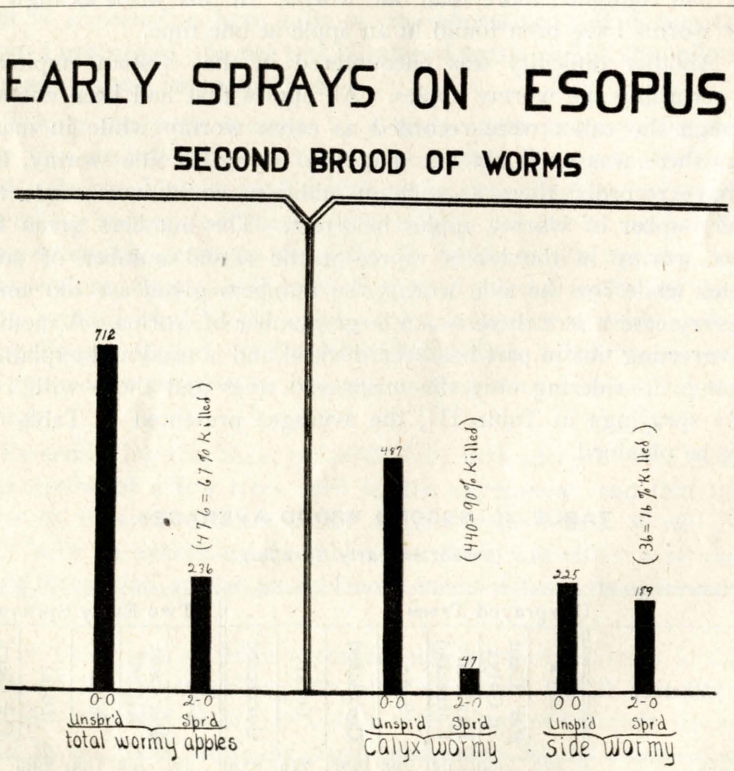

CHART VI—EARLY SPRAYS ON THE SECOND BROOD. FAVORABLE CONDITIONS.

wormy apples in the second brood and the early sprayed only 236 or that 476 worms were killed, this being 67 per cent of the total number.

Examining these results to see where the worms were killed, we find 487 calyx wormy on the unsprayed and only 47 on the sprayed, or that 440 or 90 per cent of the worms that entered the calyx during August and September were killed by poison that had been placed there in June.

Turning to the side wormy, we find the unsprayed averaged 225 while the sprayed showed 189 , or that only 36 worms or 16 per cent of those going in the side had been killed. This is an even greater per cent than would be expected as there was no attempt made to cover the outside of the apple in the first place and even if covered in June most of the poison would be gone before August 1st.

Summing up these results, we find that over two-thirds of the second brood of worms were killed by the two early sprays and that over nine-tenths of those killed met their death in the calyx. These results are presented graphically in Chart VI.

EARLY SPRAYS ON BEN DAVIS.

In this block the unsprayed trees did not have apples enough to go around and so many of them had a worm in the calyx and one in the side and a few had more than two worms.

Under such conditions, the total results as given are of little value. The calyx wormy, as explained above, is correct however. Examining the table we find that on the unsprayed trees there were 198 calyx wormy apples while on the sprayed trees there were only 41, showing that 157, or 79 per cent, of the worms that went in the calyx were killed by the early sprays.

From the same source we find that on the unsprayed trees there were 41 side worms while on the sprayed there were 106. This of course could not be true—a sprayed tree should not have more worms than an unsprayed one under like conditions. The real explanation is that of the original 106 or more side wormy apples on the unsprayed trees, 75 or more had other worms go in at the calyx so that they were counted as calyx wormy. Then to get at the real results these 75 or more apples on the unsprayed trees should be counted as twice wormy and added to the side wormy column. Adding the 75 would not make the table absolutely correct for in the Esopus, where there was no doubling up, there was 16 per cent

of the side worms killed. We have no means of getting at the actual numbers, however, and this factor will necessarily be neglected.

Adding the 75 to the side wormy and consequently to the total wormy, will give us 304 worms on the unsprayed trees and 47 on the sprayed ones, showing 157 or 51 per cent of the whole number were killed.

Summing these results, it is found that under these conditions slightly over one-half of the second brood of worms were killed and that as far as the results show all of those killed found their poison in the calyx.

EARLY SPRAYS ON THE SUTTON BEAUTY.

Under the conditions found here, there were more worms in the second brood on the early sprayed trees than on the unsprayed ones simply because there were more apples left to be wormy. There were not nearly enough to around on the unsprayed and scarcely enough on some of the sprayed. The fact that there were some apples on the sprayed trees that contained more than one worm and many on the unsprayed that contained more than two, makes it impossible to get at the exact number of the calyx wormy. Even under such conditions, the difference between the sprayed and unsprayed is quite marked.

On the unsprayed trees there was an average of 665 calyx wormy and on the sprayed only 231, showing 434, or 65 per cent, killed in the calyx. Examining the side wormy we find 197 on the unsprayed and 638 on the sprayed. This can only be interpreted as in the case of the Ben Davis on the ground that at least 441 of side wormy apples on the unsprayed trees had another worm go in the calyx. Adding this 441 to the side wormy and to the total, we get 1303 wormy on the unsprayed and 869 on the sprayed. The 434 killed in the calyx were equal to 33 per cent of the whole number of worms and as there can be none shown to be killed on the sides, this number must stand as the total killed.

AVERAGE RESULTS.

The conditions in the different blocks were so different that the results are best considered separately and, in connection with the infestation, some few facts may be gathered from the averages

and these will be presented here while the rest of the discussion will be reserved for another head.

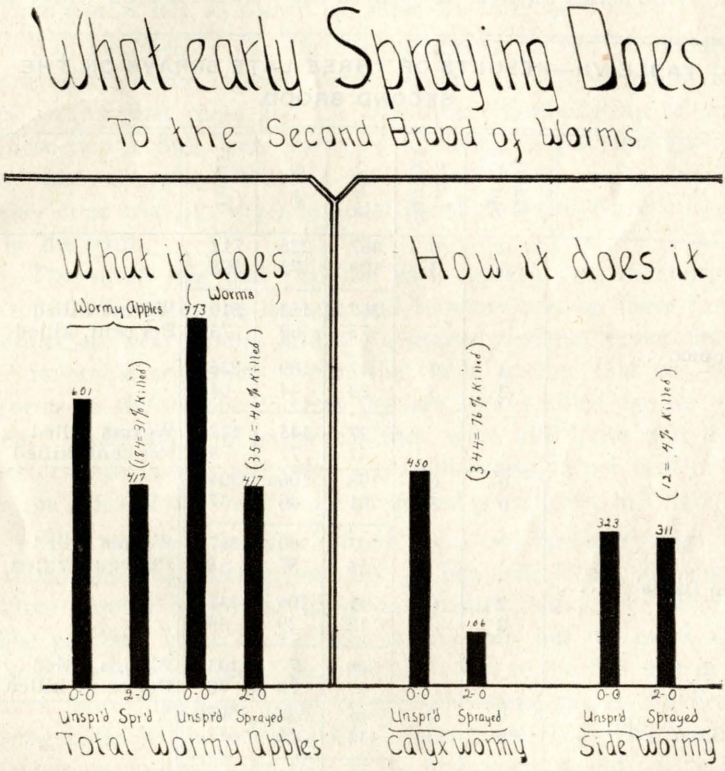

CHART VII—EARLY SPRAYS ON THE SECOND BROOD. AVERAGE CONDITIONS.

Taking the corrected figures for the last two varieties, they give an average of 773 wormy on the unsprayed trees and 417 on the sprayed ones, showing 356, or 46 per cent, killed. Considering the calyx wormy apples, the average of the unsprayed trees is 450 and of the sprayed ones 106, showing that 344, or 76 per cent, of the calyx worms found the poison. By the method of correcting, the side wormy were considered to be equal except for the few killed in the Esopus which only amounted to four per cent of the whole. These facts are presented graphically in Chart VII.

EFFECT OF THREE LATE SPRAYS ON SECOND BROOD.

The value of the late sprays was tested in the Smart and Hatch orchards in two parallel series of experiments, as shown in Table III. One series on trees unsprayed early in the season where every

TABLE VII—RESULTS OF THREE LATE SPRAYS ON THE SECOND BROOD.

	Early Sprays	Late Sprays	Calyx	Side	Total	
Esopus	0	0	487	225	712	
	0	3	120	73	193	
			367	152	519	Worms killed
			75	68	73	Per cent. killed
	2	0	47	189	236	
	2	3	20	44	64	
			27	145	172	Worms killed
			57	77	73	Per cent. killed
Ben Davis	0	0	198	106a	304b	
	0	3	91	46	37	
			107	60	167	Worms killed
			54	57	55	Per cent. killed
	2	0	41	106	147	
	2	3	15	29	44	
			26	77	103	Worms killed
			63	73	70	Per cent. killed
Sutton Beauty	0	0	665	638c	1303d	
	*0	3	411	202	613	
			254	436	690	Worms killed
			38	68	53	Per cent. killed
	2	0	231	638	869	
	2	3	71	157	228	
			160	481	641	Worms killed
			69	75	74	Per cent. killed
Average of the 4 tests under favorable conditions.	x	0	202	289	491	
	x	3	56	76	132	
			146	213	359	Worms killed
			72	74	74	Per cent. killed
Average of the 2 unfavorable tests, (Corrected-)	0	0	431	372	802	
	0	3	251	124	375	
			180	248	428	Worms killed
			42	67	53	Per cent. killed

* really is 1-3; a, b, c, d, corrected results.

worm killed could be definitely credited to the late sprays and the other on trees that had been sprayed twice early in the season and consequently had a much smaller number of worms in the second brood and already had poison enough there to destroy about half of the worms left, as shown by Table VI and Chart VII.

On two out of the three experiments on the previously unsprayed trees, the records were obscured by lack of apples for all the worms that came and the consequent doubling up of worms. These two records were corrected in the same way that they were for the early sprays, but still the per cent killed was far below the other four tests, giving additional proof that this correction is below the truth.

The three sets that had the early sprays and the unsprayed Esopus all had apples enough and to spare and on these four the results are very similar and are averaged together under the head of favorable conditions. From this table we see that out of 491 worms on the unsprayed trees the late sprays killed 359, or 73 per cent. Examining to see where they were killed, we find that 72 per cent of those in the calyx were killed and 74 per cent of those in the side. These results are presented graphically in Chart VIII.

The two sets in which there were not apples enough to go around show an average of only 53 per cent killed, although the actual number of worms killed was greater than in the other case. The per cent killed on the side is still fair, but the calyx wormy show less than one-half killed, probably due to the fact that in many cases more than one worm entered the same calyx, the first one being killed by the poison while a later one lived. This would not happen on an unsprayed tree as the first worm would not be killed. These results are shown in Chart IX.

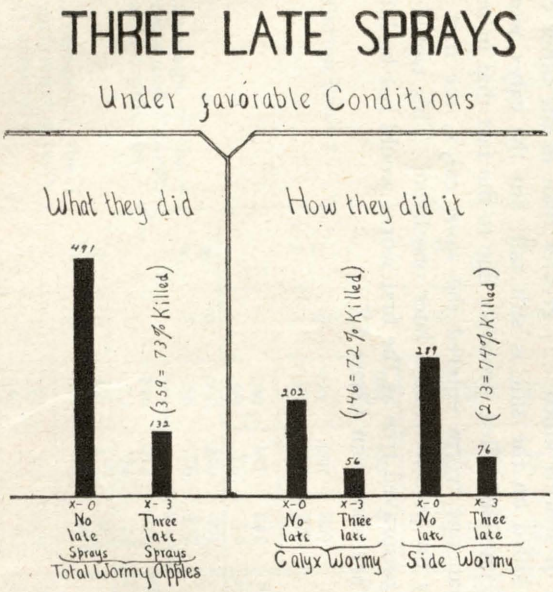

CHART VIII—LATE SPRAYS UNDER FAVORABLE CONDITIONS.

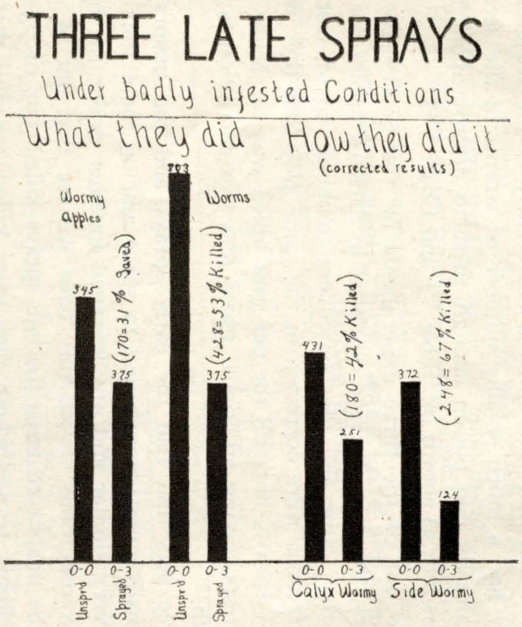

CHART IX—LATE SPRAYS UNDER INFESTED CONDITIONS.

As explained before (page 73) the actual protecting value of three late sprays when applied alone cannot be tested on an unsprayed tree in a sprayed orchard. To get at this value the results in the Hoggan orchard as shown in Table VIII are appended.

TABLE VIII—RESULTS ON HOGGAN ORCHARD FROM AUG. 1ST ON.

Tree No.	Windfalls Aug. 1st on				Picked				Totals			Variety
	Wormy			Sound	Wormy			Sound	Wormy Under Bands	Wormy	Sound	
	Calyx	Side	To ta		Calyx	Side	Total					
UNSPRAYED.												
2	253	10	263	9	31	4	35	0	214	298	9	Ben Davis.
3	171	10	181	2	21	2	23	2	111	104	4	Gano "
4	264	12	276	3	61	9	70	0	145	346	3	
5	258	10	268	3	52	3	55	0	150	323	3	Ben Davis.
8	241	39	283	10	18	0	18	0	94	301	10	Lawyer "
10	113	6	119	2	6	0	6	0	77	125	2	
Av'r'ge	217	15	232	5	32	3	35	0	132	267	5	
THREE LATE SPRAYS.												
1	179	14	193	9	47	6	53	7	220	246	16	Ben Davis.
6	295	20	315	21	69	12	81	17	164	396	38	" "
7	213	22	235	15	37	9	46	4	189	281	19	Lawver.
9	176	3	179	0	26	4	30	0	211	209	0	"
11	193	8	201	0	54	4	58	8	218	259	8	Gano
12	80	4	84	2	47	3	50	10	95	134	12	Gano.
A'v g	189	12	201	8	47	6	53	8	183	254	16	

There is no need of giving long series of comparisons on this table. The fact that the unsprayed trees had no sound apples at picking time and the sprayed ones an average of only eight is sufficient. The only real difference between them was that on the unsprayed trees the apples were practically all wormy in the calyx

and in addition had from one to six more holes in the sides, while on the sprayed trees there were nearly as many calyx-wormy, but the extra side holes had been much reduced in numbers. As far as protecting the crop was concerned, however, there was very little difference.

A first brood of 320 worms is of course a badly infested condition, but still not as bad as the Sutton Beauty and only a little worse than the Ben Davis, so that it is a fair comparison with these blocks.

There is no way of correcting this table to show the number of worms killed because there were no early sprayed trees in the orchard. The fact that more worms came under the bands on some trees than there were total apples is rather significant. As it is, the table is of little value, except as a warning to those who would advise neglecting early sprays.

SUMMARY OF THE RELATIVE VALUE OF EARLY AND LATE SPRAYS.

Summing up the results of the former tables, we find that the two early sprays killed an average of 220 worms per tree in the first brood, and 356 in the second brood, or a total killing value of 576 worms, while the three late sprays killed only 359 worms. But even this comparison does not show the relative protecting value of the early and late sprays, because in killing the 220 worms in the first brood, the early sprays prevented at least five times as many worms from appearing in the second brood, or 1,100, so that the entire protective value of the early sprays was 576 killed plus 1,100 prevented, or 1,676, while the entire value of the late sprays is in the number of worms killed in the second brood, or 359. Consequently the early sprays were nearly five times as valuable as the late ones. These facts are presented in Chart X.

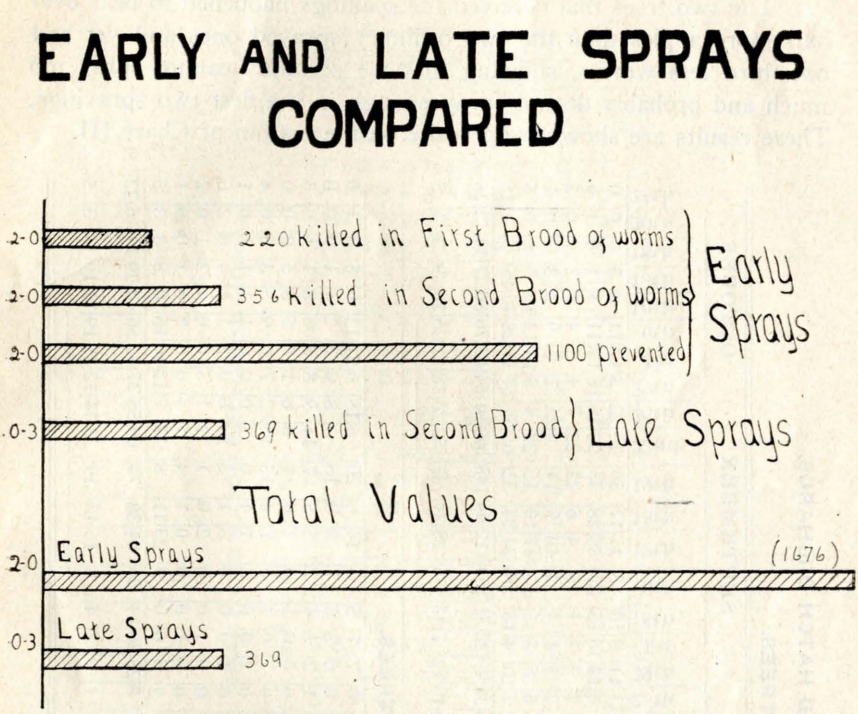

CHART X—RELATIVE VALUE OF EARLY AND LATE SPRAYS.

HOW MUCH SPRAY TO APPLY AT ONE TIME.

To test the value of heavy spraying as against just thoroughly wetting the tree, one tree each of Esopus and Missouri Pippin was sprayed until the water stood in puddles under the trees, then left an hour and sprayed in the same way again. This was done at each of the first two sprayings, and the results compared with ordinary twice sprayed trees of the same kinds with the following results:

TABLE IX—HEAVY SPRAYING VS. ORDINARY SPRAYING.

	Wormy	Sound
Two sprayed Esopus	227	655
Two sprayed Missouri Pippin	84	1031
Average	155	846
Soaked Esopus	158	1032
Soaked Missouri Pippin	49	1634
Average	103	1333

TABLE X—BAND RECORD SMART AND HATCH ORCHARDS.

UNSPRAYED TREES.

Tree No.	JULY										AUGUST									SEPTEMBER						OCTOBER						
	2nd	6th	8th	11th	14th	18th	21st	23rd	26th	29th	1st	3rd	6th	9th	12th	15th	18th	22nd	25th	29th	1st	5th	8th	12th	15th	19th	22nd	26th	29th	3rd	6th	10th	13th	18th	20th	25th
4	4	9	6	16	21	13	13	8	14	5	4	3	5	4	3	3	1	3	11	11	3	10	18	17	17	30	19	22	3	12	11	8	3	0	0	0
5	12	26	12	38	44	31	22	18	14	20	19	3	11	14	11	4	6	5	8	13	10	15	27	30	28	35	23	16	16	12	11	3	1	0	1	0
8	4	21	10	25	26	19	10	17	13	8	3	14	2	7	6	3	1	0	3	7	1	1	5	4	6	22	22	7	4	5	4	3	2	0	0	5
9	1	9	8	24	23	15	10	9	11	11	13	2	5	0	3	5	2	0	2	3	1	4	2	10	9	14	9	11	2	7	9	2	3	3	0	1
12	4	4	6	7	13	10	7	6	9	5	2	4	2	7	4	3	5	6	6	5	3	5	13	17	10	15	22	4	5	13	13	10	3	6	0	5
16	1	1	0	10	13	16	13	13	8	11	1	4	6	8	24	11	9	2	1	10	4	16	38	34	24	32	65	31	24	34	28	40	15	5	1	15
Total	26	70	42	120	140	104	75	71	69	60	42	30	31	40	51	29	24	16	31	49	22	51	103	112	94	148	160	91	54	83	76	66	27	14	2	26
Daily Av.	6	17	21	40	47	26	25	35	23	20	14	15	10	13	17	10	8	4	10	12	7	13	34	28	31	37	53	23	18	21	25	16	9	3	1	5

TWO SPRAYED TREES.

1	0	0	2	3	5	3	3	4	3	0	0	0	2	0	2	2	1	3	0	7	7	5	5	14	6	20	6	18	6	21	12	6	3	0	1	0
6	0	2	0	1	7	3	1	1	3	0	3	3	2	3	2	4	0	2	0	6	2	3	7	8	9	15	3	8	0	3	2	4	1	0	0	0
7	0	0	1	0	0	0	0	0	0	0	0	5	4	0	1	3	1	0	1	2	3	4	2	5	5	7	14	9	8	5	8	8	1	4	0	3
10	0	0	0	0	0	2	1	0	1	0	0	0	1	0	0	0	2	1	0	0	0	1	0	1	0	1	0	0	1	0	5	3	5	0	0	0
11	0	0	0	1	1	0	2	3	5	1	1	2	3	0	3	0	3	2	0	7	0	1	3	7	4	13	15	2	7	0	9	5	3	5	0	4
17	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	2	0	0	2	0	0	3	1	1	0	1	0	0	0	1	1	1	1	0	1
18	0	3	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	3	1	5	10	6	0	3	1	1	4	0	2	6
19	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	2	0	1	2	1	3	0	0	4	2	1	0	2
20	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	4	1	4	0	0	2	0	1	0	0	1
21	0	0	0	1	3	1	0	1	1	2	2	0	3	0	0	2	1	1	2	3	6	0	4	23	11	8	17	7	12	10	16	10	8	3	3	5
Total	0	5	3	8	17	10	8	9	13	4	7	10	16	4	8	11	10	9	3	28	20	14	24	64	38	74	69	55	37	42	56	42	29	14	6	22
Daily Av.	0	1	2	3	6	3	3	5	4	1	2	5	5	1	3	4	3	2	1	7	7	4	8	16	13	19	23	14	12	11	19	11	10	3	3	5

The two trees that received the soakings happened to bear over half more apples than the two ordinary sprayed ones and yet had one-third less worms, showing that we certainly cannot spray too much and probably do not spray enough in the first two sprayings. These results are shown graphically on the bottom of Chart III.

TABLE X—BAND RECORD; SMART AND HATCH ORCHARDS—(Cont.)

FIVE SPRAYED TREES.

2	0	0	2	3	3	4	4	1	1	3	3	1	0	0	1	2	0	0	0	1	5	5	4	2	3	5	2	4	2	5	3	2	0	0	0	0
3	2	8	6	11	17	21	10	5	3	10	3	6	3	6	10	2	5	2	4	6	1	4	3	13	6	6	7	2	2	4	5	4	2	0	0	0
13	0	1	5	11	3	7	11	4	4	1	1	5	3	6	3	2	3	3	0	1	2	1	6	12	3	5	9	3	0	4	6	1	3	3	0	1
14	0	0	0	0	0	0	0	0	1	1	0	1	1	0	3	0	1	1	0	2	0	0	0	0	1	0	0	0	0	3	1	0	1	0	0	0
22	0	5	0	4	7	3	3	7	3	0	0	5	0	3	2	0	0	1	5	2	5	3	8	8	4	11	15	16	5	2	0	4	3	1	0	4
23	No Record													0	0	2	0	1	0	1	1	0	0	2	1	1	1	2	0	1	0	0	0	0	1	0
24														0	0	2	1	0	1	2	0	0	0	1	1	1	2	0	0	0	0	1	1	0	0	0
25														0	1	0	0	0	1	1	0	1	1	0	0	0	3	3	1	2	1	2	2	0	0	1
26														0	0	0	0	0	3	0	2	0	1	1	1	1	0	4	0	3	2	0	1	0	0	0
27														3	0	0	0	1	1	2	1	0	0	1	0	0	4	1	1	1	0	0	1	0	0	0
28														1	0	0	0	2	0	1	1	0	0	1	0	1	3	0	1	0	1	1	1	0	0	1
Total	2	14	13	29	30	35	28	17	12	15	7	18	7	19	20	10	10	11	15	19	18	14	23	41	20	31	46	35	12	25	19	15	15	4	1	7
Daily Av.	1	4	6	10	10	9	9	9	4	5	2	9	2	6	7	3	3	3	5	5	6	4	8	10	7	8	15	9	4	6	6	4	5	1	1	1

BAND RECORDS.

Bands were placed on all check trees in the experiment, and the worms counted and killed every three or four days throughout the season with the results shown in Table X.

These records do not show as distinct a separation into broods as those of the previous year (See Bulletin 87). This is no doubt because many of these worms came from moths that hatched out in the fruit cellar and moths from such places do not usually appear as early as those in the orchard. Thus a small part of the first brood was so late that it overlapped the early ones of the second brood.

Bands were placed on all the trees in the College Orchard and removed every ten days throughout the season. The periods were too long for accurate separation of the broods, but the summary will serve to show the value of banding and indicate the broods.

TABLE XI—SUMMARY OF BAND RECORD IN COLLEGE ORCHARD.

	July			August			Sept.		Oct.		
	7	16	27	7	16	26	8	20	3	15	31
47 Trees Summer Apples.....	98	306	281	88	80	79	146	131	(Picked)		
37 Trees Winter Apples.....	219	399	258	55	108	123	236	437	265	146	24
Daily Average Summer Apples	14	34	26	8	9	8	11	11	(Picked)		
Daily Average Winter Apples..	31	44	23	5	12	12	18	36	20	12	2

Even here however the two broods are distinctly seen. Averaging these results with those found in the Smart and Hatch orchard we find the greater number of the first brood coming under the bands in the ten days on either side of July 18th, while, on account of a cooler summer and several rains, the second brood did not reach its worst until about September 22nd, the greater number of worms coming down in the 15 days on either side that date. This would give 66 days as the average time between the broods. This is no doubt a little too long. The later worms from the fruit cellar appearing after the poison was partly washed off and when there were more good hiding places between the apples and under leaves, would be more likely to live and thus throw the big end of the second brood a little later than it otherwise would have been.

BAND RECORD IN MR. CAMPBELL'S ORCHARD.

Mr. Campbell banded his trees a little too late to get the first worms that came down, but still the record shows the first brood maximum in the first line and also shows the outside infestation on the first few rows. A badly infested orchard only 70 rods away on this side contributed most of the extra worms. Each row, where full, contained 24 trees and, when it is considered that the average is only three worms per tree in the first brood and for the side farthest away from the infestation only about two, it shows a well sprayed orchard.

TABLE XII—BAND RECORD, MR. CAMPBELL'S ORCHARD.

Row No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
July 25.....	101	81	25	30	53	29	35	26	19	22	21	15	23	22	27	20	7	15	10
Aug. 1-2.....	68	38	7	19	32	18	17	13	4	18	14	6	9	5	10	11	9	6	7
Aug. 10.....	52	42	16	14	16	17	8	7	5	11	6	4	5	9	7	9	4	6	2
Aug. 19-20.....	53	45	18	9	29	21	10	19	12	10	5	9	5	9	16	19	27	17	4

VALUE OF BANDING.

From Table III we get the following summary of the results of banding on the first brood of worms. The wormy apples are from the total wormy up to August 1st, the worms caught being the total up to August 10th, allowing ten days for the worms to come out of the apples.

TABLE XIII—WORMS CAUGHT UNDER BANDS 1ST BROOD.

	Wormy Apples	Worms Caught	Per cent. Caught
The seven unsprayed trees averaged.....	199	128	64
The 2 once-sprayed trees averaged.....	193	116	60
The 13 twice-sprayed trees averaged	21	12	57
Total of 22 trees.....	2037	1295	63

From the above table, we find that on the unsprayed trees where there were the most worms, two-thirds of them were caught under bands and even on the sprayed trees with but few worms left that over half of them found their way under the bands and were destroyed. These results are presented graphically in Chart XI.

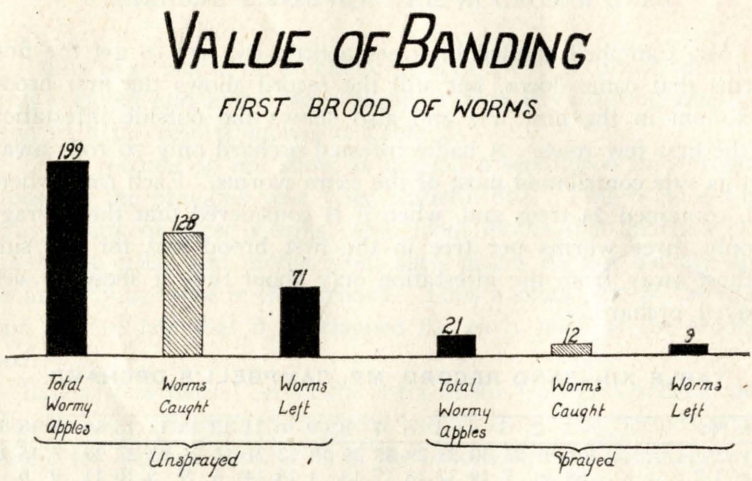

CHART XI—WORMS CAUGHT UNDER BANDS; FIRST BROOD.

From Table III we find the results in the second brood to be as follows:

TABLE XIV—WORMS CAUGHT UNDER BANDS 2ND BROOD.

	Wormy Apples	Worms Caught	Per Cent. Caught
The five unsprayed trees averaged	437	225	52
The 22 sprayed trees averaged	251	57	23
Total of 27 trees	7955	2430	31

The smaller proportion of worms caught under the bands in the fall was probably largely due to the fact that at this season of the year spiders, ants, wasps, and other predaceous insects are very active and capture a great many of them. Some apples fall off with the late worms in them and, in an uncultivated orchard, many of these worms would hide in the rubbish instead of going back to the tree, and there were still a few worms in the apples when picked.

The great value of the banding is of course in the worms caught in the first brood and destroyed, thus preventing from five to ten times that many apples being destroyed in the second brood. If three-fifths of the first brood of worms are destroyed, that means that nearly three-fifths of the second brood damage is prevented. In this particular case, the 1,295 worms caught in the first brood

no doubt saved from 50 to 75 bushels of apples on the 22 trees banded, and the 2430 caught in the second brood reduced the infestation for the next year by one-half.

HOW TO BAND.

Several different styles of bands were used at first and the one that caught the most worms was finally adopted for all. It consisted of a strip of burlap (gunnysacking) 12 inches wide and long enough to go around the tree twice. This was folded lengthwise four inches from one edge and then wrapped around the tree with the four-inch strip inside and the fold up; after passing it around twice, a large carpet tack was pushed in with the thumb to hold the end. This makes a band of four tight thicknesses at the top and two loose ones below. The worms crawl down over the tight part and hide under the loose flap and then work back up to the tight part to spin up. Worms do not like a hiding place open above, as they seem to know that a rain will run down the tree trunk and wet them in that kind of a place.

The bands shoud be placed on the trees two or three weeks after the blossoms fall and removed every ten or eleven days and the worms killed, until the first brood of worms is all down, or until about August 20th; after that they may be left on until picking time and the second brood worms all killed at once. Under no circumstances should bands be left on more than 12 days in the early part of the year, as in that case the worms will begin to hatch and the bands will do more harm than good. Do not leave bands on over winter, as the storms wash them out so that they are thin and the worms do not like them the next year.

The best method of killing worms is to use a sharp jack knife and cut them in two as the band is unrolled. Care must be taken to get those that fall to the ground and others that stick to the bark or get into cracks, etc. Banding would probably be an injury rather than a help if only the worms that came off with the bands were killed.

WORMY APPLES AT PICKING TIME.

In comparing the figures in this bulletin with the ordinary results obtained by counting apples at picking time, it must be borne in mind that the figures given here are for every apple that set on the trees and not simply those found on at harvest time. To get at the relative number of wormy apples found on a tree at picking time

compared with the total number for the season, the following summary has been compiled from the results in Table II.

TABLE XV—WORMY APPLES ON TREES AT PICKING TIME.

Times Sprayed	Total Wormy for year	Wormy on Tree at picking time	Per cent on Tree at picking time
Unsprayed Trees averaged	753	258	34
2 Sprayed Trees averaged	441	182	41
5 Sprayed Trees averaged	158	59	37
Average	451	166	37

From this table it is seen that it makes little difference whether a tree is sprayed or unsprayed, only about one-third of the original number of wormy apples remain on the tree a picking time. This varies, however, very greatly in different varieties as the following summary by varieties will show.

TABLE XVI—WORMY APPLES ON TREE BY VARIETIES.

	Total Wormy	Picked Wormy	Per cent Wormy on Tree
Sutton Beauty averaged	651	148	23
Ben Davis averaged	223	100	45
Esopus averaged	304	232	76

In this case, the Sutton Beauty were not picked until too late, while the other two varieties were picked in good time. Almost all apples that are wormy in the first brood fall before picking time, and many of the earlier ones of the second brood also decay and drop. Several orchards were visited this season in which two-thirds of the crop was on the ground in August. The above comparisons are shown in Chart XII.

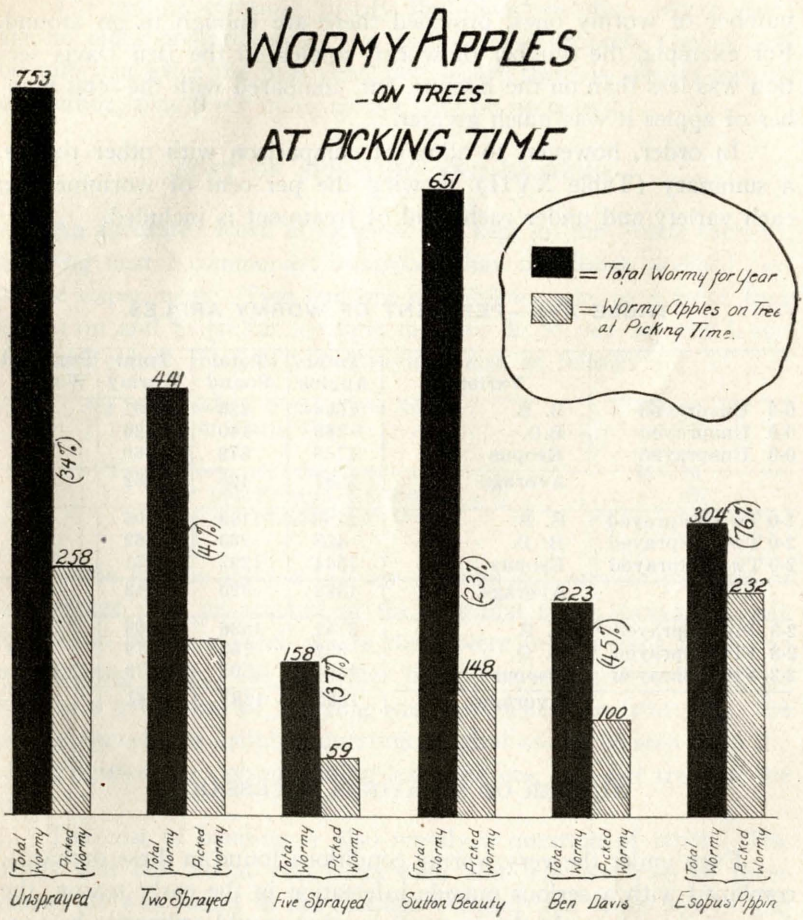

CHART XII—WORMY APPLES FALL BEFORE PICKING TIME.

PER CENT OF WORMY APPLES.

All the way through the bulletin the comparisons have been made between the actual number of wormy apples on the different trees and not between percentages of worminess as is usually done. A study of the records of a number of years' work showed that the worms were almost evenly distributed between the bearing trees, without much regard to the number of apples as long as they were well distributed on the tree. An examination of Chart III shows that the number of apples on a tree makes little difference with the

number of wormy ones, provided there are enough to go around. For example, the number of wormy apples on the Ben Davis section was less than on the Esopus, but, compared with the total number of apples it was much greater.

In order, however, to allow of comparison with other results, a summary (Table XVII) showing the per cent of worminess in each variety and under each kind of treatment is included.

TABLE XVII—PER CENT OF WORMY APPLES.

	Variety	Total Apples	Total Sound	Total Wormy	Per cent Wormy
0-0 Unsprayed	S. B.	1556	225	1301	84
0-0 Unsprayed	B.D.	566	140	426	75
0-0 Unsprayed	Esopus	1739	879	860	49
	Average	1287	425	862	67
2-0 Twice Sprayed	S. B.	2105	1199	906	43
2-0 Twice Sprayed	B. D.	438	269	169	39
2-0 Twice Sprayed	Esopus	1544	1293	251	16
	Average	1362	920	442	32
2-3 Five Sprayed	S. B.	2152	1886	266	12
2-3 Five Sprayed	B. D.	832	753	79	9
2-3 Five Sprayed	Esopus	1584	1505	79	5
	Average	1522	1381	141	9

NUMBER OF SPRAYINGS NECESSARY.

Even under the very wormy conditions found in these orchards, combined with a serious outside infestation in the early season, the five sprayings brought the crop out in what would ordinarily be considered a good condition, showing that there are few, if any, orchards in Utah that could not be handled with that number of sprayings, provided the first two were put on in the right way and the right time. On the other hand, as seen in the Hoggan orchard, the three late sprays did very little good when the early ones were not applied.

The results in the Esopus and Missouri Pippin sections are still more encouraging and show that, where there was not serious outside infestation, the two early sprays alone would give 90 per cent or more of the picked apples sound. What the results will be another year with a much smaller number of worms to start with, can only be conjectured.

The results certainly justify the statement that, where there are no other orchards near, two early sprays properly applied will be sufficient after the first year, but, where there is serious outside infestation, that three more sprays may be necessary.

COST OF SPRAYING AND BANDING.

An accurate record of expense was kept on the Smart orchard, as being nearer commercial conditions than the Hatch orchard part of the experiment. Two and one-half dollars was paid for a man and team and $1.50 for a single man, or $4.00 per day for labor. At these prices, the first two sprayings cost as follows:

4½ days labor, 2 men and team	$17.00
7 pounds of Paris Green	1.75
Total Cost of Spraying	$18.75
Cost per Tree (211 trees)	.09
Cost per Bushel (700 bu.)	.02¾

These figures are too low for the cost per acre or per tree of an average crop on account of the fact that these sprays are only applied to blossoms, and, where there were no blossoms there was no spraying done. On the other hand, the cost per bushel is too high as a great deal of spraying was done where no fruit set. The cost of spraying is mainly a question of labor as can be seen from the above figures, the poison costing less than one cent per tree for the year.

The cost of banding is also mainly a question of labor. The bands will cost about two cents each and will last two or three years. It was found in the College orchard that from 200 to 300 bands could be examined in a day, depending upon the number of worms found. Each band will have to be handled about eight times during the season, counting the time they are put on and their final removal, with a total cost as follows:

Cost of Band per year	.01 cent
Labor of Examining per year	.05 cents
Total Cost per tree per year	.06 cents

The three late sprays can be applied much faster than the two early ones, because then spraying stops before the tree drips, so that the cost of the three late sprays will not be as great as of the early ones.

Then in an average year with an average crop, the cost of properly taking care of an eight or ten year old tree would not exceed the following:

Cost of 2 Early Sprays per tree	10-15 cents
Cost of Banding	4- 6 cents
Total Cost per tree	14-21 cents
Cost per Bushel Apples	1½-2 cents

For a neglected orchard or for one surrounded by neglected trees, the cost would be somewhat higher, as follows:

Cost of Early Spray and Banding as above	14-21 cents
Cost of three late sprays	8-12 cents
Total Cost	22-33 cents
Cost per Bushel Apples	2- 3 cents

SUMMARY AND CONCLUSIONS.

The codling moth can be controlled even under badly infested conditions by careful, thorough spraying and banding.

To get the best results from the early sprays, they must be applied in the form of fine drops driven with force straight into the bottom of the calyx cups.

To do this, it is necessary to have a good pump, plenty of hose, an extension pole, a flat spray nozzle set at an angle, and it is also necessary to get up in the air and spray down.

The *only* time for the first spray is just after the blossoms fall and before the calyx cups close.

The two early sprays killed almost nine-tenths of the worms up to August 1st (First Brood).

Enough poison remained from the early sprays to kill two-thirds of the worms that came after August 1st (Second Brood).

The three late sprays killed three-quarters of the second brood of worms.

The early sprays are worth much more than the late ones. They kill almost as many of the late worms as the late sprays do and besides save a great many apples from being wormy by killing most of the early worms that otherwise would multiply.

About two-thirds of all the worms of the year go into the blossom ends of the apples. The system of spraying that kills the greatest number of these will be the most successful.

In a neglected orchard or where there are neglected orchards near, it will be necessary to spray five times.

In a good orchard, more than a quarter of a mile from any infested one, two early sprayings and banding will control the codling moth.

Late sprayings alone will not save the crop in a badly infested orchard.

Most of the failures in spraying in the past have been due to the fact that the calyx cups were not filled with poison.

Spraying costs a mere trifle as compared with the increase in price of the fruit.